



Astrobiology Discovery (Part 1 of 3):

[Adapted from *Astrobiology: An Integrated Science Approach*]

What is it?

When Earth formed, it was devoid of life, but now it is completely covered with life forms, from the desert to the ocean floor. In this activity, we will explore what scientists think about how life began, and how it is still being formed today.

Students will create a storyboard for a possible video documentary

This activity discusses topics related to National Science Education Standards:

MS-LS4-2: *Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*

- This activity encourages students to analyze their definition of a living organism and explain their ideas to others.

Materials (per team):

Consumables, not provided by NASA:

- Scratch Paper
- Crayons and/or colored pencils

Equipment, not provided by NASA:

- Computer with access to the internet

Printables:

- Storyboard Worksheet

Artifact included in this kit:

- Endolith Sample and Information Sheet

Recommended Speakers from Ames:

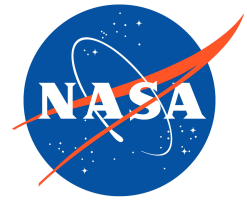
Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit

<http://speakers.grc.nasa.gov>.

Darlene Lim (Limnology, Underwater Exploration, Astrobiology)

Diane Wooden (Lunar Reconnaissance OSS, cosmic dust, dust in comets, water on the moon, astronomy, telescope, math, science, astrophysics, infrared spectroscopy, deep-freezers comets)

National Aeronautics and Space Administration



Dana Backman (Stratospheric Observatory For Infrared Astronomy, SOFIA)

Set-Up Recommendations:

- Prepare copies of the **Storyboard Worksheet**.
- Cue up the WebQuest: <http://astrobio.terc.edu/xtreme/resource2.html>
- Lay out the scratch paper for each of the students.

Procedure:

1. Introduce the activity: students will work together in teams to propose a storyboard for a video documentary. The history of life on Earth and possibly elsewhere is still being discovered today. Scientists use *fossils* (preserved living organisms) to try to understand the history of life on Earth, but also try to anticipate what life outside of Earth may look like. The collection of fossils, called the *fossil record*, helps us understand the changes (evolution, extinction, population) in the history of living organisms. Scientists can use this information in comparison with histories of other planets, and try to decipher whether or not planets have the “right stuff” to possibly have hosted life in their histories. Because of this research, scientists are redefining what they think of as a “living organism.” In this activity, students will research on the internet to learn the answers to the following questions:
 - a. What are the characteristics that help us define what is living?
 - b. What are the three domains of life?
 - c. What are some of the current scientific theories on the origin of life on Earth?
 - d. What can extreme life forms tell us about life on other worlds?
 - e. Should we expect life on other worlds to look like life on Earth?
2. We recommend breaking students into teams of 4. Pass out the **Storyboard Worksheet** to teams. Have the students work together to create scenes for their video documentary. Each storyboard should have six scenes (it is up to the teacher whether or not more scenes are optional). Students should use scratch paper for their drafts, as their **Storyboard Worksheet** will be for their final draft.
3. Students will work together to try to answer the above questions using the WebQuest suggested resources before working on their storyboards.
4. With their team, students will create a draft of their storyboards. Then, they can trade with another team for notes and edits. They will then revise their storyboards and produce a neat final version.
5. At the end of the period, have each team present their storyboards to the class.

Helpful Resources:

Astrobiology WebQuest: Online Resources:
<http://astrobio.terc.edu/xtreme/resource2.html>

NASA Astrobiology Institute:
<http://astrobiology2.arc.nasa.gov/nai/education-and-outreach/>

SpaceRef.com Student's Guide to Astrobiology:
<http://www.astrobiology.com/student.html>

Safety:

- Please be sure that students don't misuse any of the materials or stray from the Astrobiology website.



Names: _____

Storyboard Worksheet

Remember to answer the following questions:

- What are the characteristics that help us define what is living?
- What are the three domains of life?
- What are some of the current scientific theories on the origin of life on Earth?
- What can extreme life forms tell us about life on other worlds?
- Should we expect life on other worlds to look like life on Earth?

Scene 1:



Scene 2:

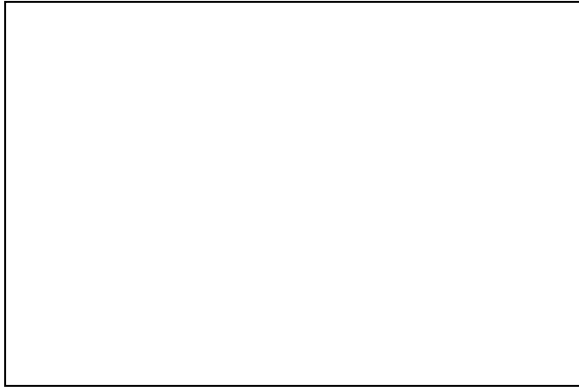


Description of Scene 1:

Description of Scene 2:

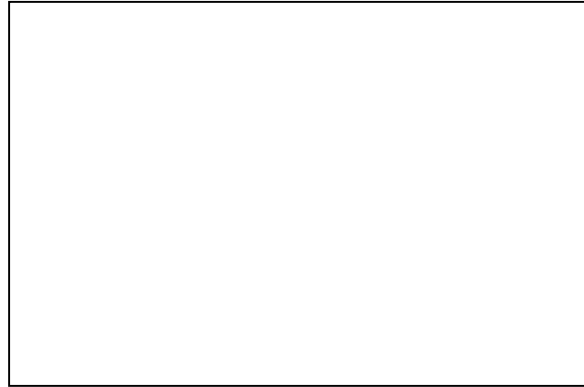
Storyboard Worksheet (continued)

Scene 3:



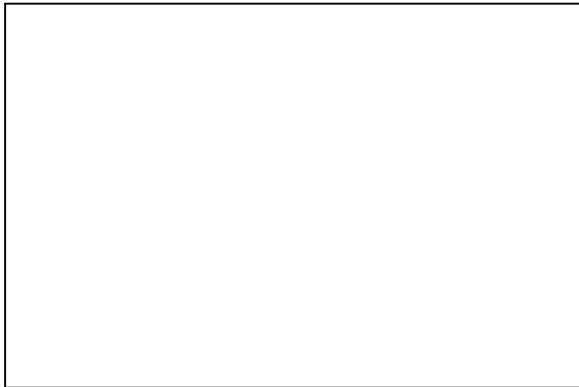
Description of Scene 3:

Scene 4:



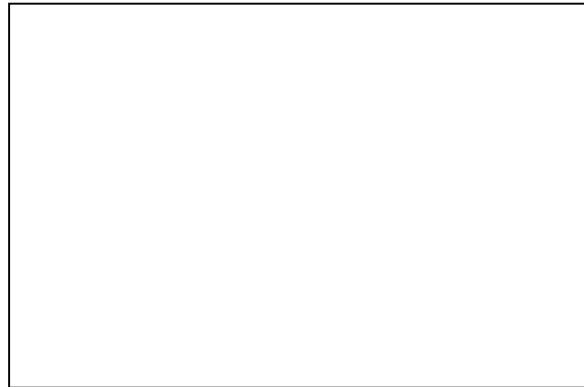
Description of Scene 4:

Scene 5:



Description of Scene 5:

Scene 6:



Description of Scene 6:



Astrobiology Discovery (Part 2 of 3):

[Adapted from Hypothesis, What is Life, and Extreme Life Card Games]

What is it?

Nature always adheres itself to patterns, rules, and laws. Sometimes these laws are easy to discern, and other times they are more difficult, but scientists are always striving to understand what they may be.

In this activity, students will play a series of card games to form an understanding of how nature behaves, how to classify life, and be introduced to extreme life scenarios.

This activity discusses topics related to National Science Education Standards:

MS-LS2-2: *Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.*

- Students will experiment to try to predict patterns in nature, represented by a set of rules in a card game. They will then question whether or not rules hold true in all situations as they experiment with extreme organisms and environments.

ETS1.B: *There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.*

- Students will follow systematic rules and restrictions within the card games that will assist in the explanation that all organisms can be reasonably predicted, but there are anomalies and outliers (extreme organisms).

Materials (per team):

Reusable Materials, provided by NASA:

- Enough decks of regular playing cards (1 per group of 2 - 8 students)
- Enough decks of What is Life? card game, found at the end of this document (1 per group of 2 - 8 students)
- Enough decks of Extreme Life card game, found at the end of this document (1 per group of 2 - 8 students)

Materials (per student):

Printables:

- Analysis Worksheet
- Conclusions Worksheet



Artifact included in this kit:

- Endolith Sample and Information Sheet

Recommended Speakers from Ames:

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Dana Backman (Stratospheric Observatory For Infrared Astronomy, SOFIA)

Set-Up Recommendations:

- Lay out the decks of playing cards for each team.
- Prepare and cut out enough decks of the *Extreme Life* and *What is Life?* card games (cards located in the **Index** section) for each team.
- Prepare copies of the **Analysis Worksheet** and the **Conclusions Worksheet**.
- Write the game rules up at the front of the classroom or, if playing stations, have the rules written out and clearly displayed at each station. We recommend creating three play areas for the three games and rotating between stations throughout the class period.

Procedure:

1. Discuss the relationship between organisms and ecosystems. All living organisms, whether they are plants, animals, etc. rely on their environment to survive. Changes in the environment can result in evolutionary traits in an organism. For example, organisms can develop a particular defense mechanism, like camouflage, that can help guard them against a prominent predator in their environment. Scientists can observe these traits in organisms to try to decipher the evolution of that organism and its environment, but they can also introduce elements into a controlled environment to see how the organism adapts. After enough time, scientists can build a hypothesis about an organism or environment.
2. Share the games with the students:

- a. First, we are going to learn to be scientists and how to conduct an experiment.
 - b. Then, we are going to look at nature around us.
 - c. Finally, we are going to theorize about places other than Earth.
3. Hand out the **Analysis Worksheet**.
4. Go through the rules of the games. Please see the **Index** for game rules.
5. Allow students to play at least two rounds of each game. Switch stations so students have the ability to play all three games.
6. At the end of the rotations, go through questions on the **Conclusions Worksheet** individually or together as a class.

Helpful Resources:

NASA Astrobiology Institute:

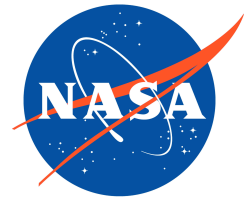
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Safety:

- Please be sure that the students don't misuse any of the materials.



Name: _____

Analysis Worksheet

Hypothesis Card Game:

Write your hypotheses here for the hands when you were the SCIENTIST.

1.

2.

3.

Were your hypotheses correct? Then you have a valid THEORY. Mark these with an asteroid (*).

What is Life? Card Game:

Write down what items you had in each column:

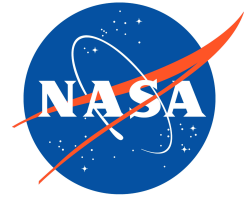
Alive

Unsure

Not Alive

Extreme Life! Card Game:

1. How many matches did you get in the first round?
2. Was it easier or harder to get matches in the second round?



Name: _____

Conclusions Worksheet

Hypothesis Card Game:

Why does the SCIENTIST have to start each hand? In other words, what is he attempting to do?

Is an incorrect HYPOTHESIS of any value to the SCIENTIST? Why or why not?

What is Life? Card Game:

For each item in the Unsure column, explain why you placed it there.

Extreme Life! Card Game:

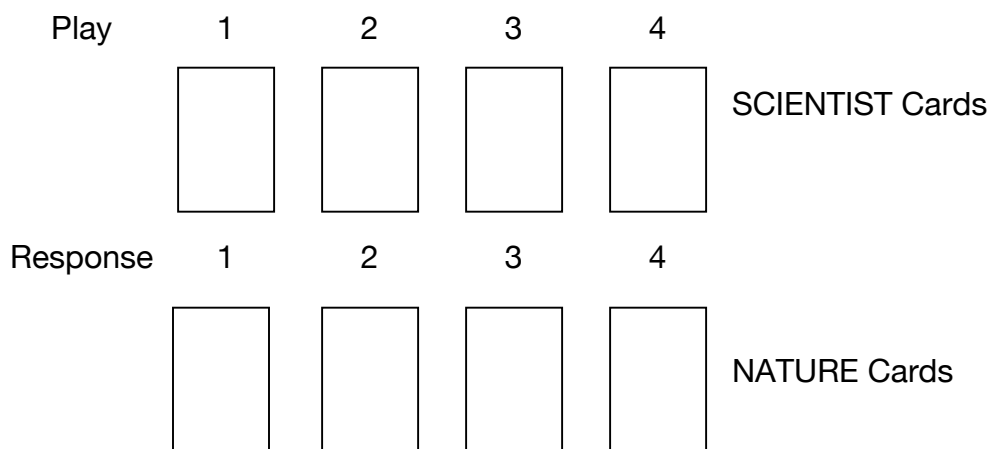
How can life conditions on Earth be used as a model for life on other worlds?



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Hypothesis Card Game

1. Divide students in teams of 1 vs. 1 (up to 4 vs. 4). It is better with larger teams of students, as they will get a chance to discuss their theories with their peers.
2. Decide which team will be the SCIENTIST and which will be NATURE. These roles will be reversed after a few rounds.
3. The NATURE team will receive the **Nature's Laws Worksheet**. DO NOT SHOW THIS SHEET TO THE SCIENTIST TEAM! We recommend that the sheets be folded in half before distribution. Have the NATURE team decide which "law" they would like to play first. Remember, nature cannot talk! It may be helpful to bring the NATURE teams outside of the classroom so they can decide on their "laws." They will play with this same law for the entire round.
4. The SCIENTIST will initiate the round by playing the first card (see "Play" configuration below).



5. Referring to their law, NATURE will respond with a card (see "Response" configuration above).
6. Each student/team will continue until the SCIENTIST thinks he/she knows what the pattern is.
7. When the SCIENTIST thinks they know what NATURE's pattern is, they will write a HYPOTHESIS on their **Analysis Worksheet**.
8. NATURE cannot talk and so it does not respond in any way, but the SCIENTISTS will test their HYPOTHESIS by laying out three more cards while trying to predict their outcomes.

9. If their predictions are correct, they now have a valid THEORY, and the round ends. If not, they will write a new HYPOTHESIS and test it until they have a THEORY.
10. Other Notes and Rules:
 - a. NATURE's cards are to be shuffled and held as a deck, facedown, but the SCIENTIST cards do not need to be shuffled (in fact, it's likely easier if they're not).
 - b. NATURE must always play the first card in the deck that fits the chosen pattern; those cards that don't fit the pattern can be set aside. NATURE may not create false patterns in order to confuse the SCIENTIST more!
 - c. If NATURE cannot play a card that fits the chosen pattern, they should play a card facedown to indicate NO DATA.
 - d. NATURE may replay a card from the table if they run out of cards that fit the pattern.
 - e. NATURE should not hint or help the SCIENTIST in any way.

What is Life? Card Game

1. Divide students up into groups of 4.
2. Hand the students the *What is Life?* playing cards and the *What is Life?* handout.
3. Have students separate the cards into three columns: **Alive**, **Unsure**, and **Not Alive**.
4. Allow students some time to work and move the items around. After they think they have come up with the final answers to their solutions, have them compare notes with other teams.
5. When they have finished, have them write down their designations on the **Analysis Worksheet**.

Extreme Life Card Game

1. Divide students up into groups of 4.
2. Hand each group a set of *Extreme Life!* playing cards. For the first round, the students will not use the Possible Extraterrestrial Habitat Cards.
3. This game is similar to "Concentration." Designate one student as the "Dealer." This student could be one that answers a question correctly (for example: Question: "Is a virus a cell?" Answer: "No. A virus infects a cell. They are usually smaller than cells.").
4. Round 1: Extreme Life on Earth
 - a. The Dealer shuffles the cards and lays them face down in two rows.
 - b. The person to the left of the Dealer turns over two cards. If the cards represent a life form and the environment in which the life form can exist, the person takes the pair and then turns over two more cards. If the cards don't match a life form with its environment, the person turns them face down again, and the next person to the left continues the play.

- c. The winner of the round is the player with the most matches.
- 5. Round 2: Extreme Extraterrestrial Life
 - a. Have the Dealer remove the Earth Habitat Cards and replace them with the Possible Extraterrestrial Habitat Cards
 - b. The Dealer will again shuffle the cards and lay them face down in two rows.
 - c. The person to the left of the Dealer turns over two cards. If the cards represent a life form and the environment in which the life form can exist, the person takes the pair and then turns over two more cards. If the cards don't match a life form with its environment, the person turns them face down again, and the next person to the left continues the play.
 - d. The winner of the round is the player with the most matches.
- 6. After two rounds, have the students fill out the last section of the **Analysis Worksheet**.

What is Life? Card Game

Jaguar

What is Life? Card Game

Virus

What is Life? Card Game

Mule

What is Life? Card Game

Rock

What is Life? Card Game

Human

What is Life? Card Game

Denim Jeans

What is Life? Card Game

Eggs

What is Life? Card Game

Elephant

What is Life? Card Game

What is Life? Card Game

Tree

What is Life? Card Game

Sand

What is Life? Card Game

Water

What is Life? Card Game

Dog

What is Life? Card Game

Computer

What is Life? Card Game

Grasshopper

What is Life? Card Game

Carrot

What is Life? Card Game

Daisy

What is Life? Card Game



Extreme Life Card Game [Taken from TERC's *Astrobiology: An Integrated Science Approach*]





<p>Organism Card</p> <p>Acid-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found bacteria living at 0.0 pH growing on the walls of caves. Most organisms live within a pH range of 5-8.</p>	<p>Organism Card</p> <p>Acid-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found bacteria living at 0.0 pH growing on the walls of caves. Most organisms live within a pH range of 5-8.</p>
<p>Organism Card</p> <p>Salt-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found halophilic bacteria living in water that is 30% salt. By comparison, seawater and human blood are about 3.5% salt.</p>	<p>Organism Card</p> <p>Cold-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found Cryotendolithotrophs living at minus 15 degrees Celsius. Earth's average temperature is 15 degrees Celsius.</p>
<p>Organism Card</p> <p>Salt-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found halophilic bacteria living in water that is 30% salt. By comparison, seawater and human blood are about 3.5% salt.</p>	<p>Organism Card</p> <p>Salt-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found halophilic bacteria living in water that is 30% salt. By comparison, seawater and human blood are about 3.5% salt.</p>
<p>Organism Card</p> <p>Heat-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found Pyrococcus furiosus living in 113°C water.</p>	<p>Organism Card</p> <p>Heat-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found Pyrococcus furiosus living in 113°C water.</p>
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<p>Organism Card</p> <p>Radiation-Tolerant Bacteria</p>  <p>Little Known Fact: Scientists have found Deinococcus radiodurans living after being exposed to radiation levels of five million rads. It can tolerate high levels of both ultraviolet radiation and radioactive decay. The lethal dose for humans is 1000 rads.</p>	<p>Organism Card</p> <p>Radiation-Tolerant Bacteria</p>  <p>Little Known Fact: Scientists have found Deinococcus radiodurans living after being exposed to radiation levels of five million rads. It can tolerate high levels of both ultraviolet radiation and radioactive decay. The lethal dose for humans is 1000 rads.</p>

Extreme Life Card Game [Taken from TERC's *Astrobiology: An Integrated Science Approach*]

<p>Organism Card</p> <p>Radiation-Tolerant Bacteria</p>  <p>Little Known Fact: Scientists have found <i>Deinococcus radiodurans</i> living after being exposed to radiation levels of five million rads. It can tolerate high levels of both ultraviolet radiation and radioactive decay. The lethal dose for humans is 1000 rads.</p>	<p>Organism Card</p> <p>Cold-Loving Bacteria</p>  <p>Little Known Fact: Scientists have found <i>Cryptotendolithotrophs</i> living at minus 15 degrees Celsius. Earth's average temperature is 15 degrees Celsius.</p>
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<p>Earth Habitat Card</p> <p>Hot springs occur when groundwater is heated and rises to the surface.</p> 	<p>Earth Habitat Card</p> <p>Processes in Earth's crust produce extremely hot groundwater.</p> 
<p>Earth Habitat Card</p> <p>Contact between volcanic magma and underground water produces pockets of hot water</p> 	<p>Earth Habitat Card</p> <p>The Arctic tundra has a layer of permafrost beneath it. Permafrost is soil locked in water ice.</p> 
<p>Earth Habitat Card</p> <p>Natural deposits of uranium can produce high levels of radiation.</p> 	<p>Earth Habitat Card</p> <p>When our atmosphere's ozone layer gets thin, Earth's surface can receive dangerous levels of harmful ultraviolet radiation.</p> 
<p>Earth Habitat Card</p> <p>Acidic groundwater is found beneath much of Earth's surface.</p> 	<p>Earth Habitat Card</p> <p>Acidic groundwater dissolves certain kinds of rocks, forming caves and producing an acidic environment for life.</p> 

Extreme Life Card Game [Taken from TERC's *Astrobiology: An Integrated Science Approach*]

<p>Earth Habitat Card</p> <p>Salt occurs in Earth's ocean water. The amount of salt in seawater is about four percent.</p> 	<p>Earth Habitat Card</p> <p>Radiation in Earth's crust comes from the decay of radioactive elements such as uranium.</p> 
<p>Earth Habitat Card</p> <p>Salt domes and brine (salty water) are often found in association with petroleum deposits.</p> 	<p>Earth Habitat Card</p> <p>The Arctic ice cap is made of water ice.</p> 
<p>Earth Habitat Card</p> <p>Water ice over two kilometers thick covers Antarctica. The coldest temperature on Earth, minus 89 degrees Celsius, was recorded in Antarctica.</p> 	<p>Earth Habitat Card</p> <p>Greenland is covered with a two-kilometer-thick sheet of water ice.</p> 
<p>Earth Habitat Card</p> <p>The evaporation of large bodies of salt water has covered large areas of land with thick layers of salt.</p> 	<p>Earth Habitat Card</p> <p>Volcanic vents occur all along the 17,000 miles of Earth's mid-oceanic ridges. The water injected into the ocean environment is extremely hot.</p> 

<p>Possible Extraterrestrial Habitat Card</p> <p>Just beneath Europa's surface, there may be large pockets of salty brine.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>During the first two to three billion years, Mars had water and volcanic activity. This combination would likely produce hot springs and underground pockets of hot water.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>Europa's ocean is probably very salty.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>The decay of radioactive elements such as uranium in the Martian crust would generate high levels of radiation.</p> 

Extreme Life Card Game [Taken from TERC's *Astrobiology: An Integrated Science Approach*]

<p>Possible Extraterrestrial Habitat Card</p> <p>Mars may have a layer of water beneath its surface. On Earth, such groundwater is often acidic.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>Acidic groundwater dissolves certain kinds of rocks, forming caves. Mars may have these kinds of rocks, resulting in an acidic environment for life.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>Ultraviolet radiation and charged particles from the sun bombard the surface of Mars, which is completely unprotected from these kinds of harmful radiation.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>Salt layers form when large bodies of salty water evaporate. Mars may have had large bodies of water that have since evaporated, possibly leaving layers of salt.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>Ultraviolet radiation bombards the surface of Europa, which is completely unprotected from this kind of harmful radiation.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>Processes in the Martian crust may heat water below the surface, producing pockets of hot groundwater.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>The Martian Polar Ice Cap is made of water ice.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>The core of the Martian Southern Polar Ice Cap seems to be made of water ice.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>Most of the Martian surface has a layer of permafrost beneath it. Permafrost is soil locked in water ice.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>Europa is completely covered by a one- to ten-kilometer thick shell of water ice.</p> 
<p>Possible Extraterrestrial Habitat Card</p> <p>Evidence suggests that Europa may have considerable volcanic activity beneath its ocean. This volcanic activity would supply Europa's ocean with large amounts of hot water.</p> 	<p>Possible Extraterrestrial Habitat Card</p> <p>The Martian surface has deposits of a kind of iron oxide called hematite. Hematite is often associated with organisms living in hot springs.</p> 



Astrobiology Discovery (Part 3 of 3):

[Adapted from *Astrobiology: Science Learning Activities for Afterschool.*]

What is it?

What is it that scientists look for when they're trying to decipher whether or not life exists elsewhere?

We learned in previous activities that "life" is pretty hard to define. In this activity, students will observe three mystery samples as they try to figure out which one contains life and which one does not.

This activity discusses topics related to National Science Education Standards:

MS-LS2-1: *Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.*

- Students will try to determine if a sample contains a living organism by adding an energy source (in this case, sugar) to the sample. Students will try to decipher the difference between an organism consuming a resource vs. a chemical reaction.

Materials (per team of 4 students):

Reusable Materials, provided by NASA:

- 3 Clear Containers, labeled #1, #2, #3
- Hand Timers

Consumables, provided by NASA:

- 9 tablespoons of sand (divided)
- ½ packet of active dry yeast
- 1 fizzing antacid tablet, crushed

Consumables, not provided by NASA:

- 1 Container of Warm Tap Water
- 6 Tablespoons of sugar, or 6 sugar packets

Materials (per student):

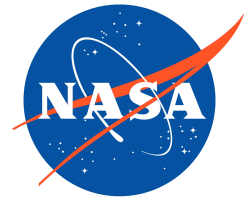
Printables:

- Life Samples Worksheet

Artifact included in this kit:

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National Aeronautics and Space Administration



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Diane Wooden (Lunar Crater Observation and Sensing Satellite (LCROSS), cosmic dust, dust in comets, water on the moon, astronomy, telescope, math, science, astrophysics, infrared spectroscopy, deep-freezers comets)

Dana Backman (Stratospheric Observatory For Infrared Astronomy, SOFIA)

Set-Up Recommendations:

- Fill a container with warm tap water.
- Set out materials for teams/students
- Set up three labeled jars for each team. Fill them with the dry ingredients as listed on the chart below:

Jar	Sand	Other Ingredients
#1	3 Tablespoons	None
#2	3 Tablespoons	½ Package Dry Yeast
#3	3 Tablespoons	1 Crushed Antacid Tablet

Procedure:

1. Introduce the activity to students with a discussion. Sometimes it may be hard for scientists to tell whether or not something is alive. Organisms are dependent on their environments and each other to survive, but what exactly is needed to support life is still under investigation. Organisms have need for an energy source (food, water, oxygen, etc.) to survive. The availability of these resources will affect the population of a particular organism. How do scientists know that an organism is consuming an energy system? Plants and animals create and use sugars as an energy source, and when they are consumed, they release a by-product of unused material. This matter can be in any form, gas, solid, or liquid. In this experiment, we will add an energy source (sugar) to three different containers to try to determine whether or not the samples are “alive.”
2. Invite all of the students to the front of the room to observe the contents of the three jars. Encourage students to use all of their senses except for taste. Have them fill out the first question on their **Life Samples Worksheet**.
3. After the observations, add one tablespoon of sugar to each jar. Have students fill out the second question on their **Life Samples Worksheet**.
4. Go around the room and add enough hot water to each sample until there is just enough to cover the sample.
5. Have students take notes after 1 minute, 5 minutes and 8 minutes. Jar 1 (with only sand) should see no activity at all. Jar 2 (with sand and yeast) should see activity after about 5 minutes and will continue to bubble. Jar 3 (with sand and antacid tablets) should fizz vigorously at first, slow down, and finally stop.
6. Have students answer questions 3 and 4 on their **Life Samples Worksheet**.
7. Have students add one more packet to each jar and answer question 5 on their **Life Samples Worksheet**.

8. Go around the room and add more water to each team's Jar 3. Have them answer question 6 and 7 on their **Life Samples Worksheet**.
9. After their worksheets are complete, have a discussion with the class. Have them share a few observations that they had with their jars. At the end, consider having the following discussions:
 - a. Have anyone ever used yeast? What for?
Explain that yeast is a tiny living thing that stays dormant (almost like sleeping or hibernation) until it is given water and food (in this case, sugar). When the yeast is "woken up" it will start to consume the food until there is none left to consume. Yeast is used to make bread rise, as it grows on the ingredients used in bread and makes bubbles, just like in Jar 2.
 - b. How was the yeast activity different from the fizzy antacid activity?
Explain that the antacid fizzed because, when combined with water, resulted in a chemical reaction that created gas (the bubbles). This reaction continued until the chemicals in the tablet were used up, and the mystery sample stopped fizzing, just like a soda can go flat. There is nothing alive in the chemicals. Because the yeast *is* alive, it will continue bubbling until it runs out of food to eat (sugar).
 - c. Now, after what we have observed today? How can a scientist tell that something is alive or non-living?
Have a short discussion. Encourage the students to look back on their answers from the first activity to see if their opinion has changed. Ask everyone to contribute, and record his or her responses on the Whiteboard/Chalkboard.

Helpful Resources:

NASA Astrobiology Institute:

<http://astrobiology2.arc.nasa.gov/nai/education-and-outreach/>

SpaceRef.com Student's Guide to Astrobiology:

<http://www.astrobiology.com/student.html>

Safety:

- We recommend not using hot water as it can burn, but please be sure that students do not touch the mystery samples.
- Even though there are no toxic materials in the samples, please do not let students consume any of the samples.



Name: _____

Life Samples Worksheet

1. You have now observed the three samples. Do you think any of the mystery samples contain living things? Why do you think so?

2. Sugar has been added to the sample, which can be thought of as food source (energy source). Do you see any changes in the samples?

Observation Time! Now that your teacher has added water to each of your sample, observe and take notes as to what happens in each jar:

Jar	After 1 Minute	After 5 Minutes	After 8 Minutes
#1			
#2			
#3			

3. Now that you have observed your samples for 8 minutes, do you think any of them may contain life? Why or why not?
4. What else might you want to know about the samples in order to figure out if they contain living things?
5. After adding more food (sugar) to Jar 3, does it restart the reaction you saw before? What is happening in Jar 2?
6. Does adding more water restart the reaction in Jar 3?
7. Has your opinion changed as to which Jar may contain living things? Why or why not?